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Featuring

Fresh Water Supply for
Somerset Station

Development of the
Science of Hydraulics

Vol. XII No. 8

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FRESH WATER SUPPLY FOR SOMERSET STATION MONTAUP ELECTRIC COMPANY

By Dana M. Wood*

General Description of Station

The Somerset Station of the Montaup Electric Company is located at Tidewater on the west bank of the Taunton River, a short distance above and opposite Fall River, Mass. This station, completed in 1925 by Stone & Webster, Inc., is the first instance in New England where several large independent public utilities have united under a co-operative plan for the purpose of jointly constructing and operating a modern superpower steam-generating station.

The Montaup Electric Company has been organized by three public utility corporations, as follows: Fall River Electric Light Company of Fall River, Mass.; Blackstone Valley Gas and Electric Company of Pawtucket, R. I.; and the Edison Electric Illuminating Company of Brockton, Mass., — all of which are now operating steam-generating stations. These plants will continue to carry the daily peak loads of their respective companies, while the Somerset Station will carry the combined base load of the associated companies. High-tension lines operated for the present at 66,000 volts, and designed for future operation at 115,000 volts, will transmit power from the new station to the load-dispatching centers of the companies it serves.

The initial installation of one turbine unit consists of a 30,000 kw. main generator with a 2,000 kw. direct-connected auxiliary generator. Three 1,492 h.p. Stirling boilers supply the steam. The building provides for two turbine units and six boilers. The boilers are so designed that they can quickly be changed from oil burners to pulverized coal. Provisions have been made for expanding the station to an ultimate capacity of at least 200,000 kw.

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* Of Stone & Webster, Inc., 147 Milk Street, Boston, Mass.

Ordinarily, the moderate amounts of fresh water required for general station use and boiler make-up would be purchased from a nearby municipal water supply system or would be provided by driven wells. In the case of the Somerset Station, a legislative enactment prohibits the city of Fall River from exporting water beyond its boundaries, and in the town of Somerset the domestic water supply is inadequate for so heavy a demand as would be required by the new station.

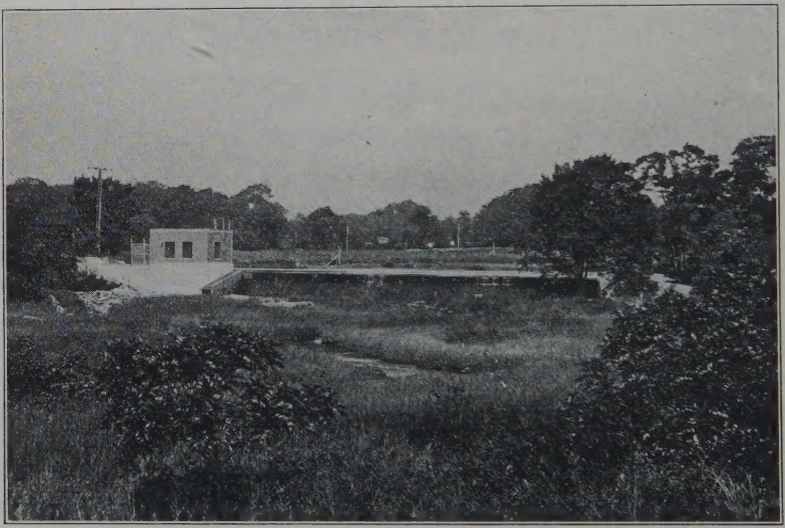

FIG. 1.—VIEW LOOKING UPSTREAM

It therefore became necessary to decide between the evaporation of tidewater and an independent source for fresh water for the normal supply. The latter was considered the more reliable method.

CONSIDERATION OF SOURCE OF SUPPLY

Two brooks adjacent to the Somerset Station were first considered as a source of supply, but were found inadequate in yield, there being no opportunity for seasonal storage to augment the run-off during dry periods.

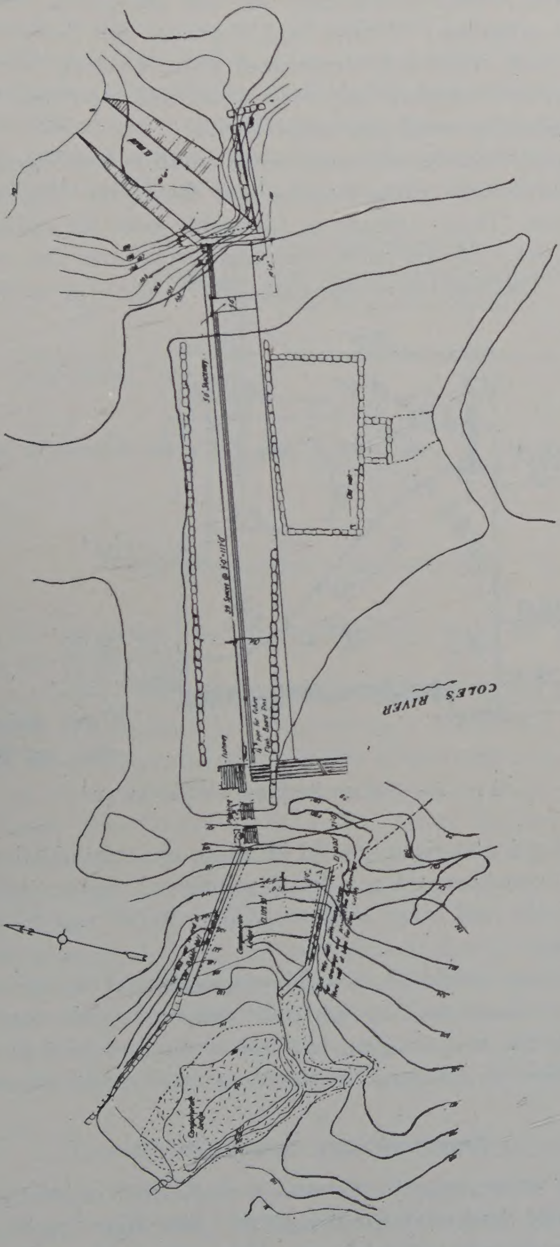

FIG. 2. — PLAN OF DAM AND APPURTENANCES

Driven wells were investigated, but the geological conditions did not favor their adoption. A thin bed of gravel and disintegrated rock overlays hard rock, with only occasional water-bearing fissures. Local experience with both shallow and deep wells indicated that the yield to be expected would be small and unreliable.

Two adequate sources of supply were found in the Segregansett and Coles rivers, the former about 8 miles and the latter 3½ miles distant from the station. Both streams at favorable sites for diversion are of the same size (11.7 square miles drainage area) and the water tested satisfactorily. The former is less extensively used for other purposes, the necessary land and rights could be more cheaply obtained, but has been seriously considered for a local municipal water supply. After balancing the cost and other features, Coles River was finally selected for development.

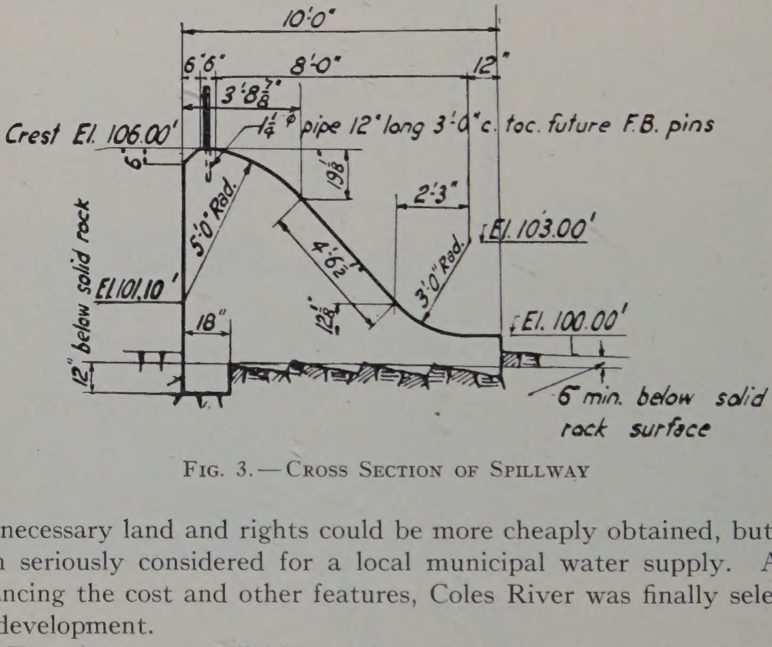

FIG. 3.—CROSS SECTION OF SPILLWAY

Two sites were available, nearly comparable so far as cost was concerned, one at an abandoned and partially destroyed dam near the mouth and the other at the next existing dam upstream, now used by a small mil for the generation of power. The lower site was finally chosen.

FRESH WATER SUPPLY SYSTEM

The fresh water supply system as developed consists of a 6-foo concrete spillway dam near the mouth of Coles River in Swansea, wit a pump house and fishway at the westerly end, and an 8-inch diamete cast-iron pipe line about 4 miles long, discharging into a concrete-lined open reservoir having a capacity of 1,000,000 gallons. The water then flows by gravity to two 150 g. p. m. and one 800 g. p. m. centrifugal service pumps on the condenser floor of the main station. These pumps supply a 20,000-gallon capacity raw water storage tank in the boiler room. For present normal operation only one 150 g. p. m. pump is required, while the 800 g. p. m. pump will carry the boiler make-up feed water in the event that the condensate must be wasted and raw water used for boiler feed.

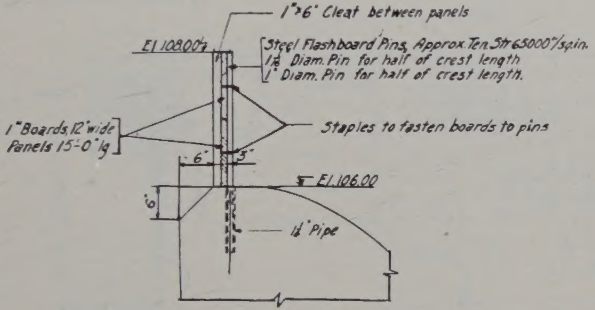
1"×6" Cleat between panels
El 108.00±
Steel Flashboard Pins, Approx. Ten. Str. 65000#/sq.in.
1⅛" Diam. Pin for half of crest length
1" Diam. Pin for half of crest length.
1" Boards, 12" wide
Panels 15'-0" lg
Staples to fasten boards to pins
6"
3"
El. 106.00
6"
1½" Pipe

FIG. 4. — DETAIL OF FLASHBOARDS

That portion of the water system used for boiler feed make-up is provided with evaporators and deaerators. The latter remove air and gases which would cause corrosion in the boilers and economizers. Raw water will be used for boiler feed purposes only under emergency conditions. Boiler feed make-up is taken from distilled water-storage tanks which have a total capacity of 300,000 gallons and is pumped to a surge tank where it mixes with the condensate from the main condenser.

It is interesting to note in comparison that a 45,000 square foot surface condenser has been provided to condense the steam from the main turbine, tidewater being used for cooling, which is supplied from two circulating water pumps having a capacity of 40,000 g. p. m. each when operating alone, and a combined capacity of 60,000 g. p. m.

DAM, PUMP HOUSE AND APPURTENANCES

At the site on Coles River chosen for development there was formerly an old earth dam about 20 feet wide on top and 9 feet high, with up and down stream faces consisting of vertical dry masonry walls. At the westerly end there was formerly a sluice gate structure, and at the easterly end there were evidences of an intake to an old mill. Both of these structures had been entirely washed out, and nothing remained of the old mill structure but a few stone foundation walls.

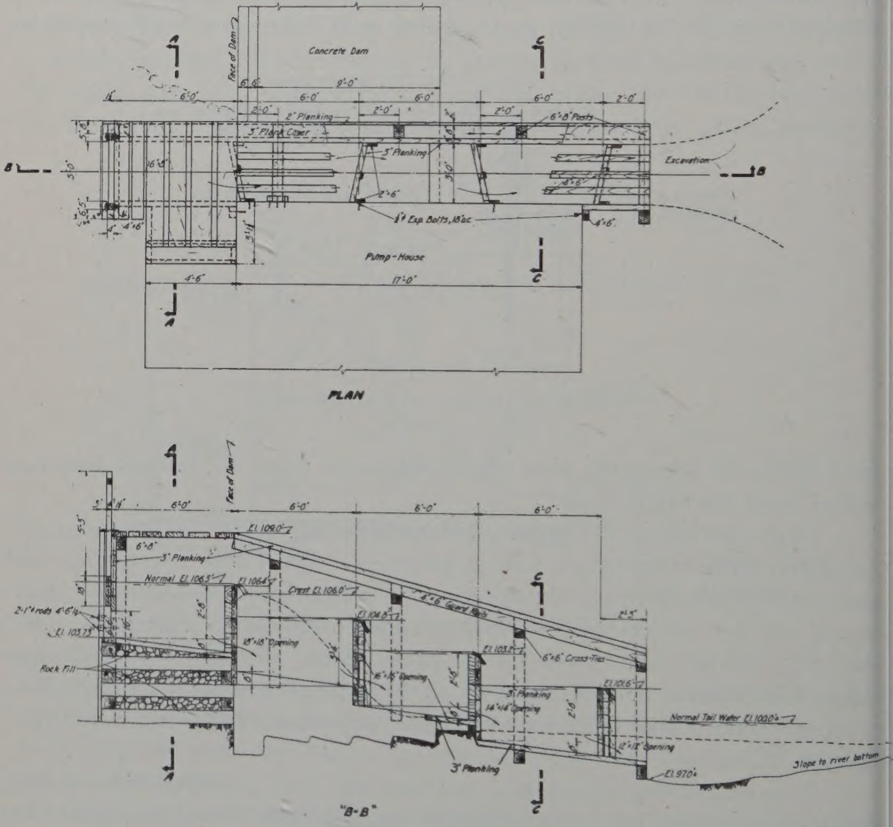

FIG. 5. — DETAILS OF FISHWAY

The existing conditions were therefore favorable to the proposed development, the pump house being built in the easterly channel where the former sluice gates were located. By locating the new dam in the downstream third, the remainder of the old dam was made to serve as a cofferdam during construction. The top three feet were removed to the level of the new spillway, the flowage rights permitting flooding to the top of the old dam. The alignment of the new dam was fixed by outcropping ledge, especially at the westerly end.

The spillway of the new dam is 117 feet long and carries 2-foot flashboards. In the east channel is a 3-foot sluiceway for the full height, used for diversion during construction, and closed by permanent stopplanks. This affords a means of draining the pond at any time.

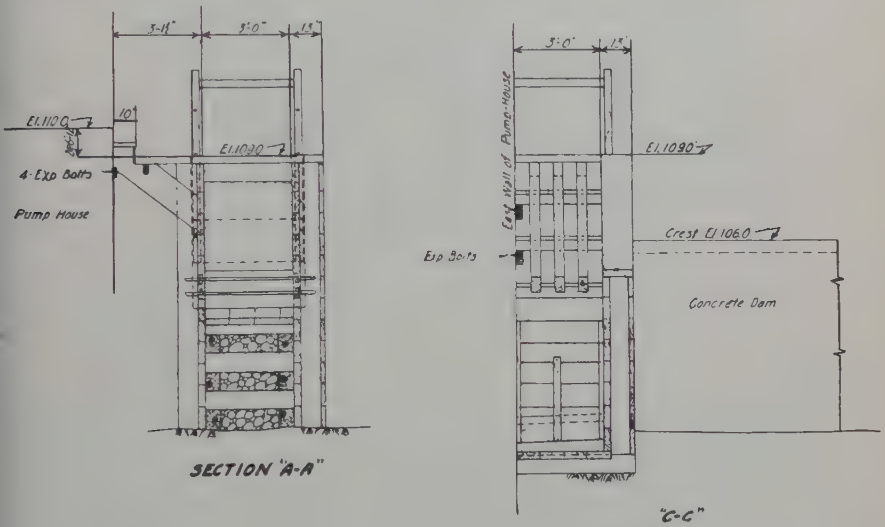

FIG. 6.—SECTIONS "AA" AND "CC" OF FISHWAY

Adjacent to the pump house is a Cail type fishway, the river being used by alewives. The fishway has proved very satisfactory.

The pump house has a concrete substructure and brick superstructure, and is 21 feet long by 17 feet wide outside dimensions. A reinforced concrete platform across the upstream side supports the operating switchboard and gives access to the building, steps leading down to the pump floor.

The two motor-driven centrifugal pumps have a capacity of 450 g. p. m. at 350 feet discharge head. They are automatically controlled by a time clock which is set for night operation at times of light load on the power company's system. Originally it was planned to install controls operated by a float in the storage reservoir and also from the power station switchboard, and this can be done at any future time when it proves desirable.

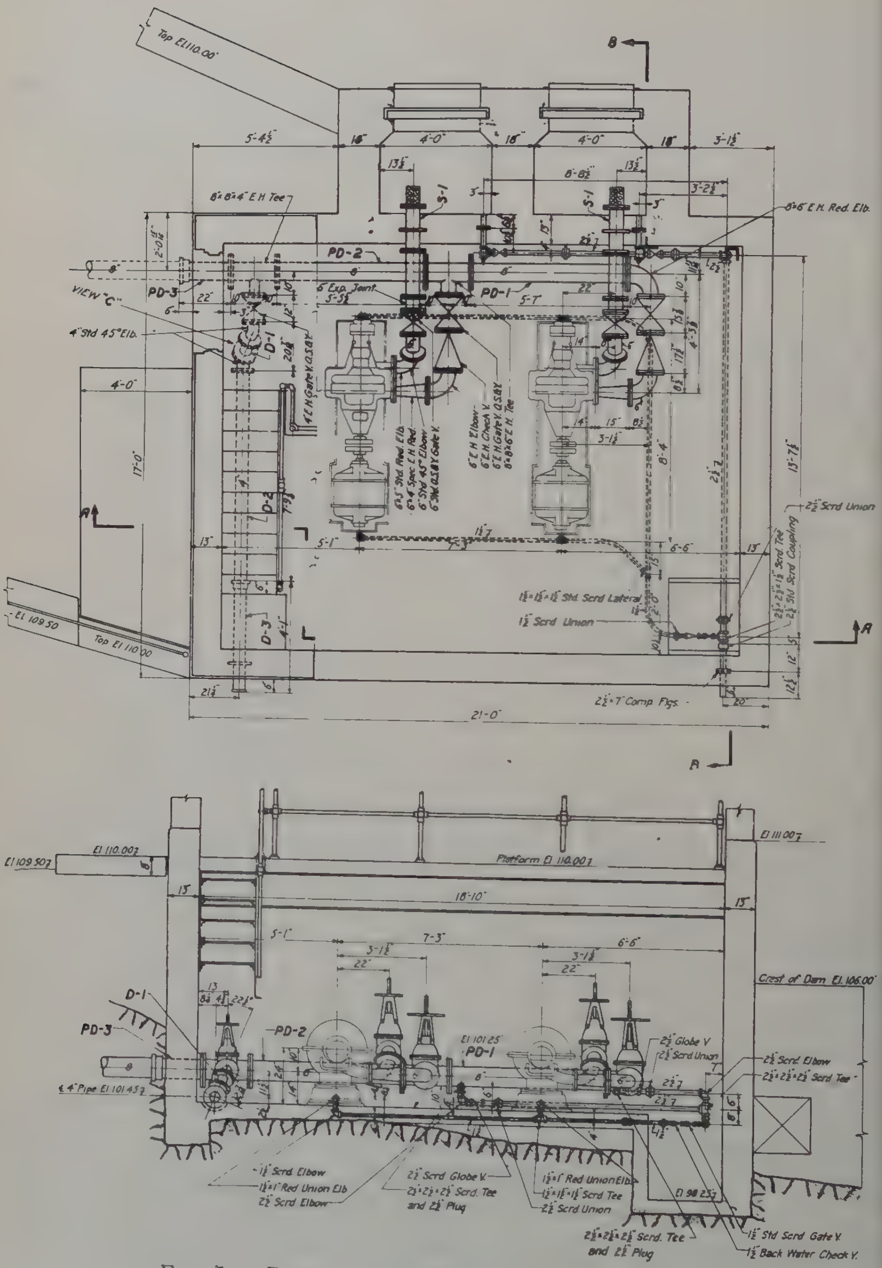

FIG. 7. — PLAN AND SECTION "AA" OF PUMP HOUSE

One pump is operated under ordinary circumstances and it is only necessary to throw a switch in the pump house to change from one unit to the other, the gate valves being adjusted by hand. The town of Swansea is provided with a number of fire hydrants, taking off from the main feeder line, and in case of a fire emergency both pumps can be used simultaneously under hand control, the operator, however, being subject to call.

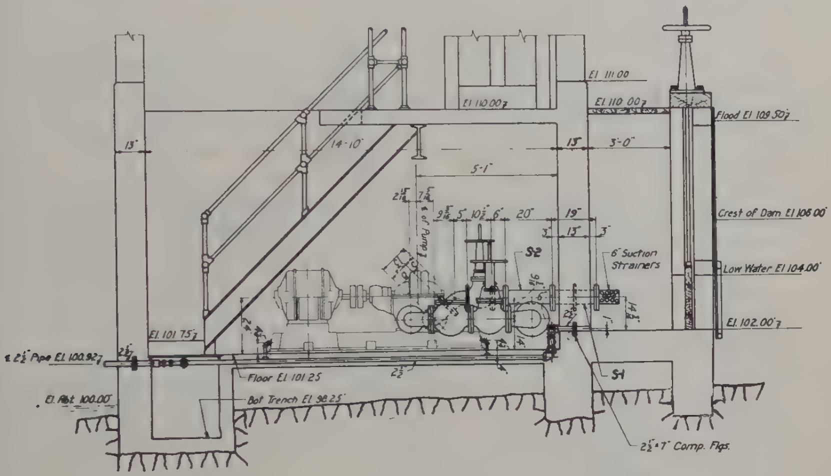

Fig. 8. — Section "BB" of Pump House

Pipe Line

The pipe line follows the private and public roads for the greater part of its length, the pipe being laid in the shoulder of the road where possible. It consists of an 8-inch diameter Class 150 De Lavaud centrifugally cast bell and spigot cast-iron pipe, furnished by the United States Cast Iron Pipe and Foundry Company. It was laid with center line not less than 4½ feet below the ground surface where not subject to excessive frost penetration, but where the character of the soil indicated the latter might occur, the depth was increased up to 5½ and 6 feet.

Leadite joints were used throughout, with satisfactory results. The line was tested to 200 pounds per square inch pressure. At its highest point an air vent was provided in a manhole.

Storage Reservoir

The storage reservoir near the station consists of a square, open, concrete-lined basin, 136 feet overall, with 12-inch side walls, 2 to 1 slopes inside, making the bottom 88 feet square. The concrete lining

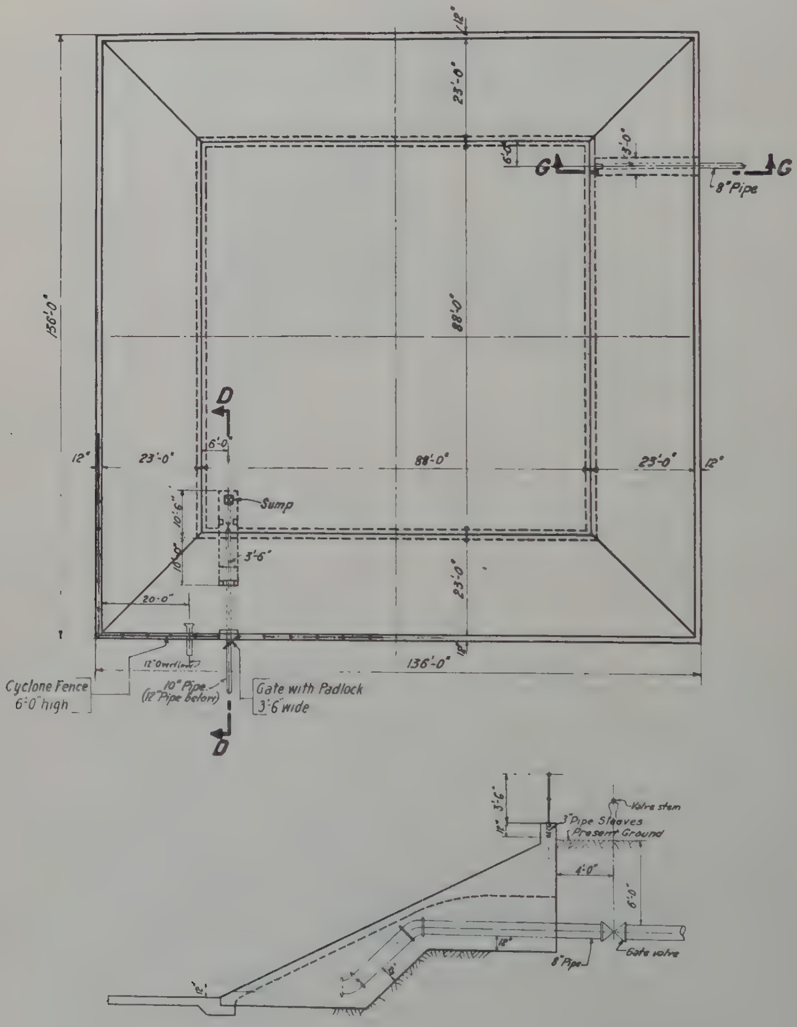

Fig. 9. — Plan and Section "GG" of Storage Reservoir

is 6 inches thick, with two layers of American Welded Fabric 2 inches from the top. An outside supporting embankment has a top width of 4 feet, is 4.7 feet high and has outer slopes of 2 to 1.

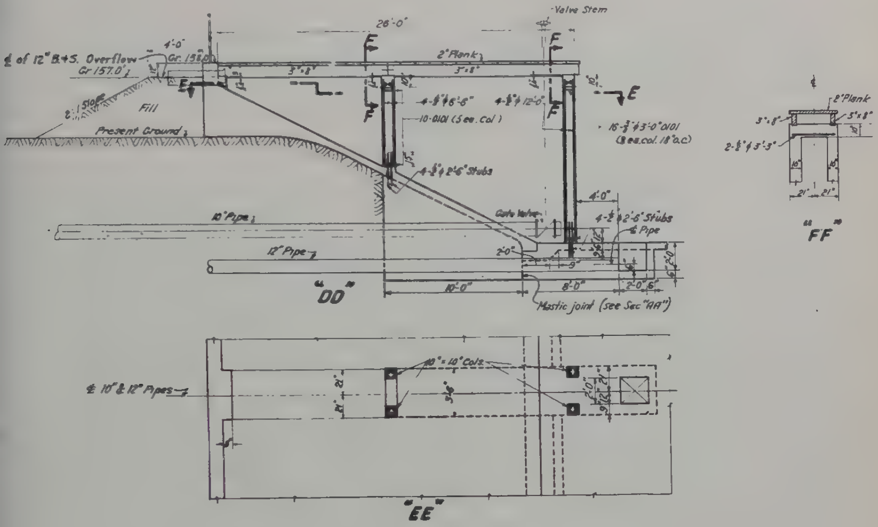

FIG. 10. — SECTIONS "DD," "EE," AND "FF" OF STORAGE RESERVOIR

STATISTICAL DATA

The following notes give further statistical data regarding the development:

Pumping Units:

Worthington centrifugal pumps direct connected to General Electric motors, 4-inch, 2-stage, 62.5% efficiency, requiring 63.6 b. h. p., at 1,750 r. p. m., with standard squirrel cage induction motors of 75 h. p., 3 phase, 60 cycle, 2,200 volts.

Pipe Line:

Total length of pipe laid = 21,072.8 lin. ft.
Average number of joints = 448 per mile.
Average material used per joint:
  Yarn, 6 oz.
  Leadite, 5 lbs.
Average number of joints poured per day of 8 hrs. = 22.
Average width of trench excavated = 3 ft.
Average quantity of material removed = 16.5 cu. yds. per lin. ft. of trench.
Length laid through marsh fields = 3,443 lin. ft.
Length laid through macadam = 1,900 lin. ft.
Length laid through shoulder of macadam = 15,729.8 lin. ft. (approx. 100 ft. of latter was spring-fed ledge rock).

THE DEVELOPMENT OF THE SCIENCE OF HYDRAULICS*

By Edward P. Hamilton†

The modern science of hydraulics is based almost wholly upon experiment. Many of the fundamental formulas are theoretical in form but modified by empirical coefficients. The science has developed in proportion to the amount of attention devoted to experimental knowledge, and it was not until about 1800 that this had become sufficient to allow quantitative results to be foretold, and then only for the more simple conditions of flow. Most of the early students of hydraulics approached it from a mathematical point of view, or simply reasoned out what they thought should be the behavior of water under certain conditions and formed their theorems accordingly.

Résumé of Early Investigations

Rome had an extensive and excellent system of water works, comprising underground conduits, open aqueducts and pipes, through which water was brought to the city from the surrounding districts. *Frontinus*, a former governor of Britain, who in the later years of his life was appointed superintendent of the water works of Rome, left us a description of the system in the year 97 A.D. He lists all the various springs and aqueducts and describes the operation of the system.‡ From this book we can obtain a good idea of the knowledge of hydraulics in Roman times. It was not realized that discharge was determined both by cross section and velocity — cross section alone was thought to be the determining factor. A gaging of the flow in an aqueduct consisted simply of measuring the width and the depth of the water. While it was realized that the velocity varied, its import was not understood, nor were there any known means of determining it. Water was doled out to consumers through orifices of size and shape determined by law. It was realized that two orifices, otherwise the same, must be set at the same depth below the surface in order to discharge the same amount.

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* This paper is essentially the same as the first chapter of the revised edition of Hughes and Safford's "Hydraulics", which is shortly to appear. Acknowledgment is due to the MacMillan Company and to Mr. Safford for permission to use it here.

† Hydraulic Engineer, 66 Broadway, Lowell, Mass.

‡ Clemens Herschel, an Honorary Member of the Boston Society of Civil Engineers, has published "The Two Books of Sextus Julius Frontinus on the Water Supply of the City of Rome, A.D., 97," copies of which are awarded annually to members of the Society for papers which have been particularly useful and commendable.

After the decline and fall of Rome all scientific knowledge was lost for many centuries. The first serious consideration given to hydraulics came from *Leonardo da Vinci* (1452–1519), who, while he is known to history largely as a painter, was an ardent scientist and one of the first engineers. He was a firm believer in study by experiment, and he made many experiments in various branches of science. One of his manuscripts that has survived shows that he had a very clear knowledge of the various conditions governing flow through an orifice. In his later years he was engineer for numerous river and irrigation projects in Italy.

The Benedictine *Castelli* (1577–1644), a pupil of Galileo, probably was the first clearly to understand that discharge depended upon both velocity and cross section. He also realized that flow through an orifice varied with the head. His pupil *Torricelli* (1608–1647), the inventor of the barometer, discovered that the flow varied with the square root of the head, rather than with the first power. *Huygens* (1629–1695) has been credited with first establishing the value of the gravity constant, "g." Thus all the necessary knowledge exists to complete the basic hydraulic formula, $V=\sqrt{2gh}$, and by 1732 we find that this law was understood and applied.

Pascal (1623–1662) came to the conclusion in about 1650 that pressure was transmitted equally in all directions through a mass of fluid at rest.

Guglielmini (1655–1710), professor at the University of Bologna, and later at Padua, published a book on measuring water in 1690. While it showed no new knowledge of the subject, it gave in one volume a description of all the methods of measuring water known at that time, and may well be considered the first real work on hydraulics. Guglielmini followed this work with another on river flow (1697), the first book on that subject, and one long famous. It covers the flow of water in rivers, river control and regulation, erosion of channels, navigation canals, and the drainage of low lands. Among its illustrations is one of a hydraulic jump. One of Guglielmini's theories shows the errors into which abstract reasoning in hydraulics may lead. Since the velocity through an orifice increased with the square root of the head, he reasoned that this must also hold good in rivers, and that the velocity would be zero at the surface and at a maximum at the bottom. Observation showed him that the velocity was not zero at the surface, but he overcame this objection to his theory by stating that the velocity in the lower levels induced motion at the surface. Guglielmini had no means of observing the velocity below the surface, so that his error has something to excuse it. *Pitot* (1695–1771), through the invention in 1730 of the tube bearing his name, was able to measure velocities below the surface, and hence to show the fallacy of Guglielmini's theory.

Daniel Bernoulli (1700–1782), a member of a famous family of scientists, made the next great step in hydraulics, that of applying the law of the conservation of energy to the flow of water. This may first have been suggested by his father, John Bernoulli, but Daniel is usually given credit for it. It was nearly a century, however, before this principle was put to practical use.

Hitherto little had been known of the relation between the flow of a river and the slope of its water surface. In 1750 the Berlin Academy offered a prize for a method of determining this relation, but met with no response. Seven years later a German, *Brahms*, published a book in which the first understanding of this relation is shown. In 1775 *Antoine de Chezy* (1718–1798) made a report on a proposed canal in which the formula known by his name ($V=C\sqrt{RS}$) appeared. This formula is still the basis used for determining flow in pipes and open channels.

The abbé *Bossut* (1730–1814) was the first to undertake hydraulic experiments in a systematic manner. He made a large number of experiments on water flowing in pipes and open channels, on water wheels, on the impact of jets, and on the resistance of water to moving bodies. What is perhaps of equal importance, he published the original data of these experiments in his work on hydraulics. Many of the experiments were on a small scale, but they were of great value, particularly in showing the way whereby further knowledge of hydraulics must be gained.

Colonel Du Buat (1732–1787), of the French Engineer Corps, made a number of experiments during the years 1780–83 by order of the French government. His experiments covered pipes, a small open channel, and a small weir. For this latter he gave the discharge formula $Q=3.46\ LH^{3/2}$, and he also gave another expression correcting for the velocity of approach. Du Buat gave a complicated formula for the flow through pipes and open channels, but here he made a serious error, saying that the resistance to flow was independent of the roughness of the channel, since particles of water filled the interstices and the only friction was that of water on water. Save for this error his understanding of hydraulics was very complete, and modern hydraulics may be said to date from the publication of his treatise in 1786. We find this book referred to in this country as the standard work on hydraulics as late as 1849.

Venturi (1746–1822) was professor at Modena and later at Pavia. He made many experiments on orifices and short tubes of various shapes, ncluding the flaring tube which is the basis of the Venturi meter, invented by *Clemens Herschel*. He also put the hydraulic jump to practical use in draining low lands.

In the year 1700 the general behavior of water was fairly well understood, and the basic relation between head and velocity was known, but the knowledge of the quantitative flow of water was very limited, in fact, almost lacking. The progress during the next century was very great, and by 1800 we find that hydraulics had become an exact science, still needing much refining, to be sure, but in its essentials correct. Bossut had given the coefficients to use for orifices and short tubes, de Chezy the formula for flow in open channels, and Du Buat those for flow in pipes and over weirs. Bernoulli's theorem was known, although it was not as yet applied, and even the hydraulic jump had been put to practical use. A man who was fully abreast with the science of hydraulics as it existed in 1800 had at his disposal practically all of the working tools necessary to the hydraulics of the present day. Many of them were crude, and a few faulty, but on the whole, with the addition of practical experience, they were sufficient to solve almost any hydraulic problem.

Eytelwein (1764–1849) translated Du Buat's works into German with certain additions of his own. He gave a different arrangement of de Chezy's formula for flow in open channels. This formula became popular in Germany and elsewhere and was known as Eytelwein's formula, but in France it gave way to a more complicated one deduced by *Girard* in 1803, $RS = a\ V + b\ V^2$. It was later realized that the term "a V" in this last formula had little effect when the velocity became moderately high, and this was often dropped, giving a return to the simpler Chezy formula.

Poncelet (1788–1868) and *Lesbros* (1788–1867), officers in the French Corps of Engineers, made a series of experiments on the discharge of orifices and weirs in 1827–28. These experiments were continued by Lesbros from 1829 to 1834. These were the first really scientific hydraulic experiments. Hitherto all experiments had been on what was really a laboratory scale. Poncelet and Lesbros' work, however, was on a large scale and was carried out very completely and exactly, so much so that their results, within their limits, have never been improved upon.

Darcy (1803–1858), a French engineer, was one of the first to devote careful study to the flow in pipes under actual working conditions. In the course of his work he studied the velocity distribution in pipes with a movable Pitot tube, worked through stuffing boxes. He came to the conclusion, in about 1850, that Du Buat's theory was wrong, and that the roughness of the pipe walls had a very decided effect upon the flow

While Darcy has generally been given credit for this discovery, it is interesting to note that a member of the Boston Society of Civil Engineers, the late E. S. Chesbrough, had come to the same conclusion at a somewhat earlier date. Basing his conclusions largely on experiments upon the Cochituate aqueduct, he decided that the coefficient in Eytelwein's formula must be varied to suit the roughness of the channel.

Weisbach (1806–1871) was the author of a very complete manual of engineering which enjoyed great popularity in its day (the first edition appeared in 1850). While he made a number of hydraulic experiments on a small scale, Weisbach largely compiled the experiments of others in his hydraulic section. Some of his experiments are still quoted in hydraulic textbooks. They were, however, made on too small a scale to be of any great value.

Uriah Boyden (1804–1879) was one of the earliest American hydraulic engineers. He had considerable to do with the early development of hydraulic turbines, and was the inventor of the hook gauge. He put Venturi's flaring tube to practical use in his "diffuser," the forerunner of the modern draft tube.

James B. Francis (1815–1892) was the most famous of the early American hydraulic engineers. In his position as engineer of the first large water-power system, he realized the necessity of additional research, particularly under the conditions usually obtaining in practice. Among his achievements were the first scientific water wheel tests made in this country, the development of the inward flow turbine, and the determination of the Francis weir formula. While the results obtained by this weir formula were only some 4 per cent different from those obtained by Du Buat's weir formula of 1786, the formula is based upon a much more exact knowledge of the behavior of the water and a precise measurement of the quantities dealt with, quantities which were much greater than any that had hitherto been used.

Henri Bazin (1829–1917) was one of the greatest hydraulic engineers As a young man he worked under Darcy, and after the latter's death he continued the experiments alone. These experiments were on the flow in open channels. Bazin applied Darcy's theory of the effect of the roughess of the wall to open channels and finally derived a formula which orrected for this effect, by the use of a coefficient which varied with the naterial forming the walls. Ganguillet and Kutter based their formula or flow in open channels to a large extent upon Bazin's experiments.

Bazin's chief fame, however, is based upon his experiments with weirs. The work of Poncelet and Lesbros had been followed by that of *Castel* t Toulouse in 1835–36, and *Boileau* at Metz in 1845–52. Francis, neanwhile, was experimenting in this country, and his work was coninued by *Fteley* and *Stearns* on the Sudbury aqueduct of the Boston Vater Works in 1877–79. Bazin's exhaustive studies commenced in 886 and lasted for a number of years. His experiments, due to their variety and precision, are perhaps the most useful which have yet been made, and formulas based upon them are adapted to a greater variation of conditions than are those of Francis and Fteley and Stearns.

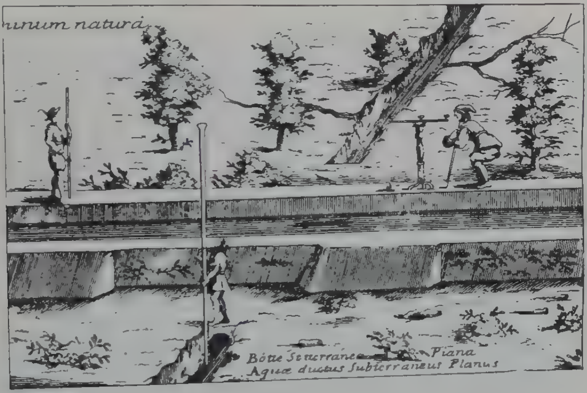


FIG. 1.—LEVELING PARTY OF 1697

The development of hydraulics until about 1700 was very slight, and consisted solely in a gradual comprehension of a few of the basic laws. The next century saw a very great advance, so that by 1800 the art had become an exact science. During the last century there were no great discoveries save the realization of the effect of the roughness of the channel upon the flow, but there was a steady development, and a very great addition to the experimental knowledge.

The study of hydraulics began in Italy and continued there for some two centuries. It then shifted to France, where it continued to develop until the modern science was evolved. The great majority of those who have contributed to the advancement of the art have been French engineers and scientists, and the French government has always been generous in furnishing funds and facilities for conducting hydraulic ex periments. Experimental hydraulics originated in France, and unti about the middle of the last century but little worth-while work was done outside of that country.

Hydraulic Measuring Devices

The science of hydraulics requires a number of special instruments with which various observations are made. The two common methods of measuring the height of a water surface, the vertical staff gage, or its equivalent, a rule measuring down to the water surface, and the glass gage tube are obvious and must have existed from early times. Bernoulli's "Hydrodynamica," 1738, shows a cherub measuring the height of a water column in a glass tube with a pair of dividers.

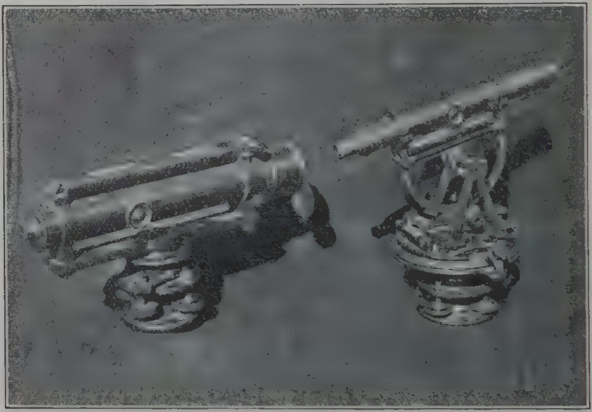


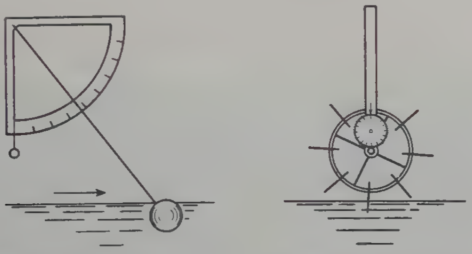
Fig. 2. — Early English Level and Transit

Probably used about 1850

The Romans had instruments with which they were able to run lines of levels. Guglielmini's "De Fluminum Natura," 1697, shows a levelman sighting through an instrument at a rod held by an assistant. The combination of a telescope with a cross hair and a level vial may have come into use about this time. It is said to have been invented by Huygens, but it was not made practical until de Chezy discovered a method of grinding the vial to a true arc. By 1737 the level existed in practically its modern form, with tripod and a four-screw levelling head.

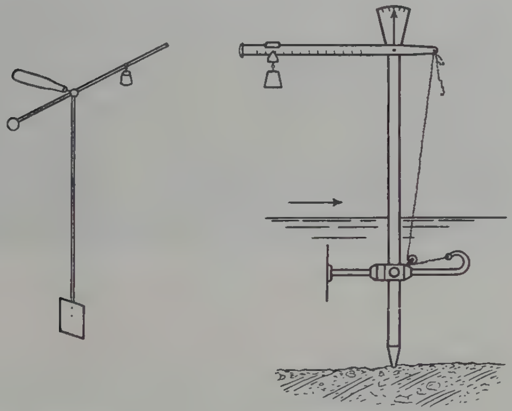
crude form of transit with both vertical and horizontal arcs was also n use at this time.

The most important hydraulic instruments are those which measure he velocity of flow. The earliest and most obvious is the surface float. ubsurface floats and rod floats soon followed, and it is not known when hey first came into use. The first scientific work with rod floats was one by Francis in 1856.



Hydraulic Pendulum

Surface Velocity Wheel



Leupold's Tachometer 1722

Bruning's Tachometer 1789

Fig. 3. — Velocity Measuring Instruments

The hydraulic pendulum, said to have been invented by Castelli, vas one of the early instruments used. It consisted of a ball, slightly eavier than water, on the end of a string. The angle of the string from he perpendicular when the ball was immersed in flowing water was read n an arc, and was taken as a measure of the velocity. Pitot's tube has lready been mentioned. At first it was largely a scientific toy, and was ot much used until Darcy turned his attention to it in about 1850.

A small, freely revolving wheel with flat blades around its rim was used to measure the surface velocity of a stream, but it was not of much practical value, since surface velocity could usually be measured by floats quite as easily.

Bruning's tachometer (1789) consisted of a flat plate opposed to the current. A scale arm and weight served to record the amount of the pressure against the plate and furnished a measure of the velocity. *Woltmann*, an engineer of Hamburg, invented his "moulinet" in 1790. This consisted of a small propeller wheel on a horizontal shaft, mounted on bearings and connected with a mechanism which recorded its revolutions. This was the forerunner of the modern current meter, which has since been made in many forms, all of which, however, are the same in principle.

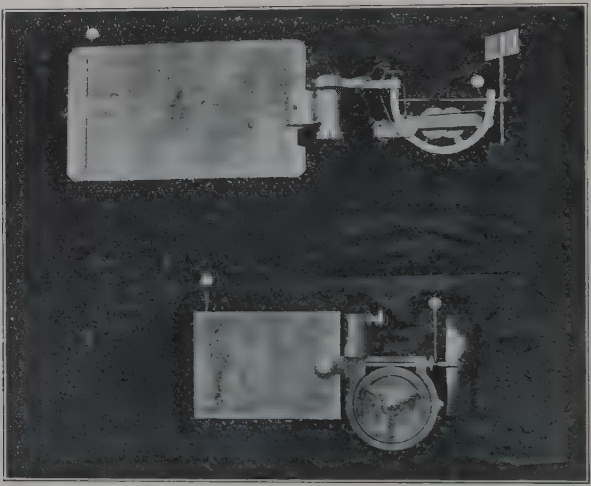


FIG. 4. — WOLTMANN'S "MOULINET" AND EARLY ENGLISH CURRENT METER

The first large water-power development was commenced at Lowell in 1821. The waters of the Merrimack River were divided among a number of mills, and it was soon found necessary to measure large quantities of water flowing in canals. In 1830 the quantity of water supplied to one of the mills was measured by a large "gage wheel." This was 15 feet long and 19.25 feet in diameter, constructed somewhat like an undershot wheel. The lower part was immersed in the tail race of the mill, which fitted it with a small clearance on the bottom and ides. The wheel revolved freely, so that, knowing its speed and the olume of water contained between two blades, the discharge could be letermined.

In 1841 *James Baldwin*, *George W. Whistler*, and *Charles S. Storrow* vere appointed commissioners to measure the water used by the Lowell nills. They caused a flume to be built, 80 feet long and 4.5 feet deep, in vhich they placed seven gage wheels, each 16 feet in diameter and 10 eet long. The wheels were fitted to run with a clearance of only a quarter f an inch at the floor and sidewalls. The water passing these wheels was neasured as before, by timing the revolutions of the wheels. The same vater was then passed through a long straight flume lined with plank. Surface floats were placed in this flume at the center and their velocity letermined. The actual discharge of the gage wheels was known, as vas the corresponding surface velocity at the center of the flume. The elation between the true mean velocity through the flume and the surface velocity gave a coefficient which was applied to subsequent surface loat measurements, giving the true mean velocity. Such were the cumbersome and expensive methods of measuring water less than a hundred years ago. A few years later Mr. Francis made his famous weir experiments, and followed them by his work on rod floats, so that gage wheels vere never used again in Lowell.

Modern Developments of the Science

We have seen that the knowledge of hydraulics gradually increased n the course of centuries until it had begun to become an exact science y 1800. The various special instruments had paralleled this development so that by this same time all our modern instruments were in xistence in a more or less crude form. One thing was yet needed to urther the progress of the art, and that was a field of application. Before the industrial revolution the field of application of hydraulics was omparatively small. Rivers were regulated to some slight extent, argely in Italy, and navigation canals were built, particularly in France. A few of the large cities had crude water supply systems of a sort, but sewerage systems were unknown. Water power was developed only in small mills, and the quantity of flow was usually more than ample to serve the mill, so that there was no particular need for a means of determining the quantity of flow.

In the nineteenth century standards of living advanced tremendously. All cities and many smaller towns built water-supply works and sewerage systems. Water-power developments increased rapidly and to such an extent that on many rivers the question of the division of water became of considerable importance, necessitating exact measurements of large quantities of water flowing in canals or races. The utilization of all the available fall on rivers brought up the question of the backwater effect caused by dams, how high a dam could be raised without damaging the next mill upstream, or without flowing out valuable lands. In the earlier days most hydraulic works had been on a comparatively small scale, and "cut and try" methods usually sufficed, but larger and more expensive works required a careful examination of the various factors entering into the case in order to determine the feasibility of the project. The need for an exact hydraulic science had risen, and the last century saw a tremendous growth in the art, particularly in the direction of refinement and amplification of existing knowledge, rather than in the discovery of any revolutionary principles.

Author's Note. — A list of the various works referred to in preparing this paper would be too lengthy to publish here, but special mention must be made of Clemens Herschel's "Frontinus" and "115 Experiments", both of which give considerable information regarding the history of hydraulics.

OF GENERAL INTEREST

PROTECTING THE CITY PLAN

Presented by Mr. Philip Nichols at the Twelfth Annual Conference of Massachusetts Planning Boards held in Boston, October 5 and 6, 1925

At the meeting of the Massachusetts Federation of Planning Boards at Worcester last October (1924) a proposed method was suggested by the present speaker of meeting the difficulties, which had hitherto proved unsurmountable, of enacting a statute which would effectively protect an official city street plan prepared and filed by a local board of survey or planning board from immediate or gradual destruction by the wilful or careless disregard of the proposed street lines by property owners, which would meet constitutional objections, and would not subject the city or town for which the plan was devised to a great and indeterminate liability for damages.*

In brief, the plan proposed was to provide that if a building was erected in the bed of a street shown on the official city plan, after the plan had been filed, the owner should have no damages for the destruction or removal of the building when the street was actually laid out and constructed as a public street. This, of course, was the provision which had previously been held unconstitutional, but the constitutional difficulties were to be met by providing that the filing of the plan with the statutory protection should be treated as the taking of an easement or restriction in the property within the limits of the proposed streets, and that the owner might recover damages for the imposition of this restriction by filing claim therefor within a limited period. It was believed that few such claims would be filed, but as a further protection to the city, it was provided that even after an award had been made by a jury on such a claim, the city might avoid liability to pay the award by rescinding the restriction.

It appears that the problem is nation-wide, as statutes attempting to protect the city plan have been held unconstitutional in every state in which they have been enacted, except Pennsylvania, and so much interest was aroused by the proposed plan that the present speaker was asked to address the International Conference on City Planning, held in New York last April, on the subject. In New York and some other states attempts have been made to meet the situation by the enactment of statutes of a somewhat different character, under the police power of the state instead of under the power of eminent domain; but no such statutes have been yet enacted. Such statutes undoubtedly run closer to the line of unconstitutionality than the proposed method under the power of eminent domain, and it is conceded even by those who advocate the police power method for their own states, that the eminent domain method is more in accord with the legal traditions and practices of Massachusetts than the method which they deem best for their own jurisdictions.

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* The paper presented by Mr. Nichols at Worcester in October, 1924, was published as Bulletin No. 16, November, 1924, by the Massachusetts Federation of Planning Boards.

A bill embodying the plan submitted at Worcester was introduced in the Massachusetts Legislature at the session of 1925 at the instance of the Massachusetts Federation of Planning Boards, but failed of enactment. The circumstances under which it failed were not such, however, as to cause discouragement with respect to its enactment in 1926. The bill was first referred to the Committee on Highways and Motor Vehicles of the Legislature. It came before that Committee for hearing on February 28. A large and representative gathering of persons interested in city planning advocated the enactment of the bill, and no one opposed it; but the Committee, after some deliberation, concluded that the bill involved so many legal problems that it should have been submitted to the Committee on Legal Affairs, and asked to be discharged from further consideration of the bill.

In due season the bill was referred to the Committee on Legal Affairs and came before that Committee at a public hearing in March. Again a large and representative gathering advocated the bill; but the Committee was frankly hesitant to approve the bill, on account of its novel character, until assured of its constitutionality from some disinterested and authoritative source; and at the same time the Committee was being pressed by the Speaker of the House to complete its work. The bill was, accordingly, immediately referred to the Attorney-General for an opinion as to its constitutionality. This opinion was rendered on April 11, sustaining the constitutionality of the proposed measure in every particular. At that time it was felt by those in authority to be too late in the session to take up a new matter which few could understand without much study, and the bill was, accordingly, referred to the next session of the Legislature.

The bill will doubtless at the 1926 session be referred at once to the Committee on Legal Affairs, which will be composed of the same members as in 1925, as there is no state election this fall. I have been assured that the members of that Committee were favorably impressed with the bill and that the disposition made of it was not with any hostile intent, and if the bill is properly followed up it ought to be enacted in the coming session.

The greatest danger is from the general failure of the public and of persons only mildly interested in city planning to appreciate that cities and towns have not now authority to adopt city street plans protected by law, and that all laws attempting to give them that power have been held unconstitutional. At the time of the International Conference some of the Boston newspapers, in commenting on the subject, and on the enormous sums which were now being spent in the widening, straightening and extending of streets, all because there had been no city plans in the past, assumed that the failure of cities and towns to provide city plans was through slothfulness or lack of foresight, and that with the present lesson before them they would use better judgment in the future. Such comments entirely ignore the whole point of the discussion, which is, of course, that cities and towns, however good their intentions, are perfectly helpless in the matter, and that the problem of giving them the power to establish a city plan that any one is bound to respect and follow and that meets the hitherto fatal constitutional objections is one that requires an act of Legislature of a novel and unusual character to solve.

While I believe that the members of the committees who heard the discussion were favorably impressed with the bill, they have many other matters to consider, and I do not think that the bill has been given sufficient impetus to carry it through the 1926 Legislature unless it is actively followed up. If any planning boards or boards of survey or other municipal bodies, or bodies of citizens interested in public affairs, desire that there should be a law under which a city plan protected by law can be adopted, the time for action will be early in 1926; and not only attendance at the public hearing before the Committee but an expression of their interest to their own representatives will be essential. The time now appears to be opportune; if the bill fails of enactment in 1926, it may be many years before it will be in a position to receive such favorable consideration again.

Editor's Note. — The above article by Mr. Nichols is presented herewith in order to familiarize those members of the Society interested in City Planning with the proposed legislation which will be considered by the coming Legislature. It is hoped that the engineers in this vicinity will assist in securing the passage of this bill which is so important in the successful carrying out of City Planning projects.

New Theories of Flow in Pipes

By Karl R. Kennison, 25 Pemberton Square, Boston

The American Academy of Arts and Sciences has recently published in the form of a memoir, notes of the late Hiram F. Mills on the flow of water in pipes. A copy of this memoir is in the library of the Boston Society of Civil Engineers. This treatise is the result of study and experimentation extending over a period of nearly half a century.

Mr. Mills' effort is probably the most painstaking attempt ever made to find the mathematical expression of the law or laws governing the flow of water in pipes. He was convinced as to the precision of such a law or general theory, and never accepted as inevitable the 3, 4, or 5 per cent discrepancies in ordinary hydraulic computations and measurements.

For example, in 36 groups of experiments involving 1,045 of his own tests on 12-inch tar-coated, cast-iron pipe with velocities ranging from 0.4 to 11.7 feet per second, the average departure of the observations from his theory is only 0.8 of 1 per cent, and for certain tests by Saph and Schoder on small smooth brass pipe only one-tenth of an inch in diameter with velocities ranging from 0.4 to 6.6 feet per second, it is only 1.5 per cent. These results are remarkable in view of the great range of velocity and diameter of pipe.

One of the earliest of Mr. Mills' deductions was that the character of the flow in a pipe undergoes a decided modification as the velocity increases. He reached this conclusion partly as a result of extensive tests with Pitot tubes, especially with minute and delicate tubes of his own design capable of registering close to the pipe walls.

Mr. Mills concluded that at low velocities water flows through a pipe smoothly, all the particles moving straight ahead, each successive concentric layer sliding easily over its neighbor, the curve of velocities probably being a parabola even to the pipe walls. The flow will continue to be of this character so long as a certain velocity is not exceeded, and this limiting velocity depends on a number of conditions. For example, the smaller the pipe or the smoother its walls or the colder the water or the nearer to the entrance into the pipe, the higher the velocity that can be maintained under this smooth or undisturbed condition of flow. This results in the interesting paradox that cold water, which is known to flow less easily than hot water, will flow more easily at a certain low velocity at which the cold water can just maintain this smooth flow and this full parabola, but which is too fast for the hot water to do so. This limiting velocity is generally too low for practical observation, since most pipes are not small and smooth enough to reveal this condition of flow distinctly.

The orderly results of the experiments become very much confused as soon as the limiting velocity is exceeded. The confusion, which is in part responsible for our different empirical exponential formulas, is reconciled by Mr. Mills to the actual confusion and eddying which starts at the rough walls and gradually penetrates toward the center as the velocity is increased more and more above that which can be maintained smoothly in contact with the walls.

Such eddying necessitates the continual regeneration of velocity in the turmoil, and uses up head proportional to the square of this velocity and probably to the square of the mean velocity in the pipe. But the extent of the cross sectional area occupied by the turmoil also increases with the velocity, so that it is not inconsistent to find some observations within this range which show the total loss of head proportional to a power of V very much greater than 2.

The extent of this eddying or disturbed motion increases as the velocity increases, up to a certain upper limit of velocity, depending on diameter, temperature, etc., at which velocity it has reached maximum penetration toward the center, a distance depending on the roughness of the pipe surface. Experiments seem to show that the disturbance does not penetrate any further than this in spite of any increase in velocity.

It would seem, therefore, that above the upper limiting velocity, after the eddying has reached and is maintained at maximum penetration, the total hydraulic grade or loss of head per foot should be composed of a small loss proportional to V plus a greater loss proportional to V^2, and this Mr. Mills has found to be corroborated by all available carefully conducted experiments.

Mr. Mills' development of these theories cannot be further explained in the limited space available here, but further reference should be made to the treatise itself.

Conference of Planning Boards

At the Twelfth Annual Conference of Massachusetts Planning Boards called by Governor Alvan T. Fuller on behalf of the Department of Public Welfare and the Massachusetts Federation of Planning Boards on October 5 and 6, 1925, a number of topics were discussed of interest to engineers.

The conference was convened by Richard K. Conant, Commissioner of Public Welfare of Massachusetts, and was addressed at the opening session by Governor Fuller and at luncheon by Hon. James M. Curley, Mayor of Boston. The program for the first day included the presentation of the following papers:

"The Work of the Year," William Roger Greeley, Chairman, Massachusetts Federation of Planning Boards.

"Accomplishments and Tendencies," Edward T. Hartman, State Consultant on Housing and Planning.

"Metropolitan Planning," Arthur A. Shurtleff.

"Regional Planning," Phillips Bradley.

"The Billboard Situation," Horace B. Gale.

"The Problem of Open Spaces," Charles W. Eliot, 2d.

"Protecting the City Plan." Discussion led by Philip Nichols and Alfred Bettman.

"Principles and Application of Betterments," Hon. Charles H. Beckwith.

"Building Lines," Edwin H. Rogers.

"The Function of Citizens' Organizations in City Planning and Zoning," Alfred Bettman, Chairman, United City Planning Committee of Cincinnati.

On the second day, an open Conference on Zoning was held, the discussion being led by George C. Gardner, "The Experiences of Our City," and W. Franklin Burnham, "A Real Estate Man's Point of View."

The following officers were elected for the ensuing year:

William Roger Greeley, Chairman.

Winthrop I. Nottage, Vice-Chairman.

W. Franklin Burnham, Treasurer.

Eleanor Manning, Secretary.

Elisabeth M. Herlihy, Horace B. Gale, Arthur C. Comey, Members of Executive Board.

Edward T. Hartman, Executive Secretary.

The Massachusetts Federation of Planning Boards, organized in 1915, is composed of 476 members, representing 81 planning boards in this State. At the conference held each year various phases of the work of these boards is discussed and many interesting papers are presented. The co-ordination of these boards, through the Federation, has resulted in much constructive work along City Planning lines.

Many of the members of the Boston Society of Civil Engineers are interested in City Planning, and a number of them are at present actively engaged as members of planning boards in the various communities. The paper on "Protecting the City Plan," presented at the conference this year by Mr. Philip Nichols, is particularly timely, and has been printed in full in another column of this JOURNAL.

Leasing of Public Oil Lands

Reorganization of the oil and gas leasing work and field administration of the public oil lands under control of the Geological Survey has been announced by the United States Interior Department.

Establishment of three field divisions under the jurisdiction of district supervisors who are engineers in charge with full authority and responsibility to conduct operations and represent the government comprises the salient feature of the reorganization. The divisions include the Rocky Mountain district with headquarters at Casper, Wyoming; the Pacific district with headquarters at Taft, California, located in the heart of the California oil fields; and the Mid-continent district with headquarters at Muskogee, Oklahoma.

Centralization of authority in the engineers in charge of these districts resulted from the constant development of operating problems necessitating immediate decision and requiring a high degree of skill in oil field operations. Up to the time of the reorganization it has been the custom to refer all questions of administration to the Washington headquarters of the Geological Survey before final action was taken. Under the new plans the engineers in charge will act on their initiative and authority.

The engineers placed in charge of the various districts include R. C. Patterson at Taft, California; J. W. Steele at Casper, Wyoming; and H. J. Lowe at Muskogee, Oklahoma. Under the new plan of decentralizing responsibility in the field, the vacancy created by the resignation of Fred B. Tough, formerly having supervision over oil and gas leasing activities in the Geological Survey, will not be filled.

A feature of the reorganization will be the periodical detail to the Washington office of the supervisors and deputy supervisors in order to keep them in close touch with Department policy and duly acquaint the chief of the Conservation Branch, Herman Stabler, and the Director of the Geological Survey, George Otis Smith, with field problems.

PROCEEDINGS OF THE SOCIETY

MINUTES OF MEETINGS

Boston Society of Civil Engineers

September 30, 1925. — A regular meeting of the Boston Society of Civil Engineers was held this evening in Chipman Hall, Tremont Temple, and was called to order by the President, Richard K. Hale, at 7.25 p.m. There were about 125 members and guests present.

The minutes of the previous meeting were approved as printed in the May Journal.

The Secretary reported for the Board of Government the names of those elected to membership:

May 14, 1925. *Members:* Charles W. Banks, Gordon G. Howie. *Juniors:* Harold L. Bartlett, William J. Downer, Irwin M. Penney. *Associate:* Harry I. Maximon.

June 26, 1925. *Members:* Boris Beresteneff, Michael J. Caddigan, Edward O. McSweeney, Arthur L. Wannlund, George L. Burke,* Arthur E. Harding.* *Juniors:* Ernest Mathers, Joseph F. Pagliarulo.

Sept. 30, 1925. *Members:* Frank W. Gilcreas, Walter W. Zapolski.

The President announced that the Society had lost the following members through death: George M. Clukas, died June 28, 1925; Willard M. Foster, died July 5, 1925; Charles W. Eaton, died July 21, 1925; Clarence A. Perkins, died September 12, 1925; and George H. Towle, died September 21, 1925. He stated that committees would be appointed to prepare memoirs.

The President announced that a few tickets were available for the launching of the airplane carrier, U. S. S. "Lexington," to be held at Fore River on October 3, 1925, and that members could obtain them from the Secretary at the close of the meeting.

He then introduced the speaker of the evening, Mr. G. H. Delano, Maintenance Engineer, Massachusetts Department of Public Works, Division of Highways, who presented an excellent paper on "Some of the Problems of Highway Operation." Although the field to be covered was large, Mr. Delano presented the subject in a clear and concise manner. His talk included a brief résumé of many of the important problems before the Department of Public Works, such as snow removal, restrictions of weights of motor trucks, lights, signs, route markers, etc. At the close of the paper there was a very interesting discussion in which a number of members took part.

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* Transferred from grade of Junior.

The meeting adjourned at 9 P.M., after a rising vote of thanks to Mr. Delano for the presentation of his paper.

J. B. Babcock, *Secretary.*

APPLICATIONS FOR MEMBERSHIP

[October 15, 1925.]

The By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

For Admission

Avery, Elwood C., Harrisburg, Pa. (Age 21, b. Brooklyn, N. Y.) Member of the senior class, civil engineering, at Tufts College. During the summer of 1923 employed on valuation work, and summer of 1925 with the Highway Department of Pennsylvania as chainman. Refers to Robinson Abbott, H. L. Bartlett, H. P. Burden, W. J. Downer, E. H. Wright.

Birkmaier, Waldo Bradford, Waltham, Mass. (Age 20, b. Montgomery, Vt.) Student at Northeastern University, and during work periods has been with R. H. Barnes and H. F. Beal. Refers to H. B. Alvord, C. S. Ell, J. W. Ingalls, W. E. Nightingale.

Bloom, Maurice, Somerville, Mass. (Age 21, b. Bialstok, Poland.) Student at Northeastern University for two years. Has been employed by Whitman & Howard, Gay & Proctor, and six months with Metropolitan District Commission. Refers to H. B. Alvord, C. S. Ell, J. W. Ingalls, W. E. Nightingale.

Hodgkins, Leonard M., Waltham, Mass. (Age 20, b. Waltham, Mass.) Student at Tufts, senior class. The past two summers has been employed by the city of Waltham on the engineering staff. Refers to Robinson Abbott, H. L. Bartlett, H. P. Burden, W. J. Downer, E. H. Wright.

Lindgren, Oscar Reinholt, Ansonia, Conn. (Age 24, b. Ansonia, Conn.) Senior at Northeastern University. During work periods has been employed by the N. Y., N. H. & H. R.R. Refers to H. B. Alvord, C. S. Ell, J. W. Ingalls, W. E. Nightingale.

McLaughlin, Edward D., Melrose, Mass. (Age 22, b. Melrose, Mass.) Graduate of Mass. Inst. of Tech. in 1925. During the summer of 1924 was engineering assistant with Melrose Dept. of Public Works. At present is structural draftsman with the Boston & Maine R.R. Refers to J. B. Babcock, H. K. Barrows, B. W. Guppy, Pusey Jones.

Miers, George Everett, W. Medford, Mass. (Age 38, b. Boston, Mass.) A student at Mass. Inst. Tech. 1906–08; 1908–10 rodman with B. & A. R.R.; 1910–11 instrumentman on land surveys with Thomas A. Appleton; 1912 with the Great Northern Paper Co.; 1913–14 with Hancock Construction Co., bridges and buildings; 1914 with T. Stuart & Sons

Co., Lynn dam; 1915–17 assistant engineer with B. & M. R.R., Maintenance of Way Dept.; 1917–20 resident engineer with Stone & Webster, Inc.; 1920 with Roberts Eng. Co.; 1921–23 with B. & M. R.R. on valuation reports; 1923–25 with Utilities Power Co. & N. H. Power Co., hydroelectric surveys and construction. Refers to Clarence E. Carter, G. Gale Dixon, R. W. Horne, J. J. Rourke, A. L. Shaw, J. F. Wilber.

ROMMER, GEORGE J., Mattapan, Mass. (Age 21, b. Chelsea, Mass.) Has been student at Northeastern University, taking mechanical engineering. With the Metropolitan Sewerage Works in 1924 as rodman, and in April, 1925, promoted to transitman in the same department, where he is at present located. Refers to R. W. Loud, Benjamin Rubin, H. T. Stiff, H. I. Wyner.

SAVERY, ARLO ROSWELL, Silver Lake, Mass. (Age 20, b. North Carver, Mass.) Graduate of Kingston High School and now a student at Northeastern University. During co-operative periods has been with the city of Brockton (Engineering Dept.) since 1924, and previous to that date was rodman with A. P. Trufant, Brockton, and draftsman with C. H. Gannett, Boston. Has also been with Charles Whitney as transitman. Refers to H. B. Alvord, C. S. Ell, J. W. Ingalls, W. E. Nightingale.

SCHRAMM, GEORGE F., Roslindale, Mass. (Age 20, b. Roxbury, Mass.) Graduate of Mechanic Arts High School in 1922, since then a student at Northeastern University. Has worked for C. H. Gannett as transitman during work periods. Refers to H. B. Alvord, C. S. Ell, J. W. Ingalls, W. E. Nightingale.

SMITH, LOUIS H., Somerville, Mass. (Age 20, b. New Orleans, La.) Student at Northeastern University. During work periods has been employed by Whitman & Howard, Inc. Refers to H. B. Alvord, C. S. Ell, J. W. Ingalls, W. E. Nightingale.

STUDLEY, JOHN FRANCIS, Wakefield, Mass. (Age 20, b. Wakefield, Mass.) Senior civil engineering student at Tufts College. Spent summer of 1925 in St. Petersburg, Fla., on land development, doing engineering work. Refers to Robinson Abbott, H. L. Bartlett, H. P. Burden, W. J. Downer, E. H. Wright.

WARREN, ROLAND A., Boston, Mass. (Age 24, b. West Springfield, Mass.) Student at Northeastern University. With Whitman & Howard during work periods. Refers to H. B. Alvord, C. S. Ell, J. W. Ingalls, W. E. Nightingale.

For Transfer from Junior

AVERELL, EDWARD S., Lynnfield, Mass. (Age 26, b. Lynn, Mass.) Graduate of Mass. Inst. Tech. in 1923. Employed for past two years by Erastus Worthington, C.E., Dedham, Mass. Refers to J. B. Babcock, C. B. Breed, H. L. White, Erastus Worthington.

MACAULAY, RALPH FAIRFIELD, Cambridge, Mass. (Age 27, b. Boston, Mass.) Graduate of Northeastern College, Evening School of Engineering; 1918–25 employed by B. & M. R.R., Engineering Department. At present assistant track supervisor. Completed a short course in railroad engineering at Tufts College in 1918. Refers to F. T. Flynn, E. L. Lockman, J. J. Rourke, D. P. Steward.

NEW MEMBER

FRANK W. GILCREAS, 14 Beacon Street, Boston, Mass.

DEATHS

GUNNAR E. LOEFQUIST .	July 21, 1925
CLARENCE A. PERKINS .	Sept. 12, 1925
GEORGE H. TOWLE . .	Sept. 21, 1925

BOOK REVIEWS

"Sampling and Testing of Highway Materials," by Wm. H. Barton, Jr., Assistant Professor of Highway Engineering, University of Pennsylvania, and Louis H. Doane, Associate Professor of Civil Engineering, Pennsylvania Military College. First edition, 1925. McGraw-Hill Book Company, Inc., New York. 355 pages.

In this book the authors have brought together the information relevant to accepted practice in the testing of the various highway materials together with the standard or more commonly accepted specifications relating to them. Considerable emphasis is laid upon the necessity for the careful and intelligent selection of samples for test. Proper methods are carefully outlined for the various materials, such as cement, aggregate (coarse and fine), road metal, brick and the bituminous substances.

Laboratory procedure for the study of road material in general has been thoroughly detailed in a clear and comprehensive manner. The text abounds in valuable suggestions concerning the technique of laboratory manipulation. These should prove extremely helpful to the student who is approaching the subject for the first time, and may well be profitable even to those of some experience.

The proper equipment for a very complete laboratory has been given careful consideration. The arrangements suggested may well serve as a model which the individual investigator may modify to meet local needs or limitations.

Each section is furnished with an ample bibliography which to the thorough and advanced worker opens a wide field for study and research reading.

One of the outstanding features of the book from the educational point of view is the collection of questions following each important subdivision. These queries are not overnumerous, but they are leading and searching. A thoughtful consideration of them will carry the earnest student very far toward a clearer conception of the significance of the work he has been carrying on.

Throughout the authors have held in mind not only the needs of the student, but have so carefully outlined the best methods of attack that the instructor will find his labors greatly lightened. The requirements of the engineer have also been considered, and in the specifications, charts and tables there appear much information of continued value to the practical man.

"Street Traffic Control," by Miller McClintock, Assistant Professor of Municipal Government, University of California, Southern Branch; and Consultant to the Los Angeles Traffic Commission. First edition, 1925. McGraw-Hill Book Company, Inc., New York. 233 pages.

This book treats of the various problems met with in street traffic control, their origin, difficulties and extent, and offers some suggestions for improving various commonly met difficulties.

The first chapter is introductory, treating of the origin and growth of the traffic problem. The second chapter covers traffic surveys and how and where to make them.

Chapters three and four treat the causes of congestion, viz., street plan, character of traffic and its regulation.

Chapter five gives general rules for replanning a street system to aid traffic, and chapter six tells what minor changes in streets may be made in order to increase street capacity.

The remaining eight chapters describe the handling of traffic, covering not only the actual work of handling, but the organization of traffic control bureaus and the handling of the questions of parking, punishment of offenders against the traffic code, traffic signs and traffic signals.

As a whole, the volume gives a very good bird's-eye view of the problem, suggestions as to handling, and information as to how it is being handled in various places.

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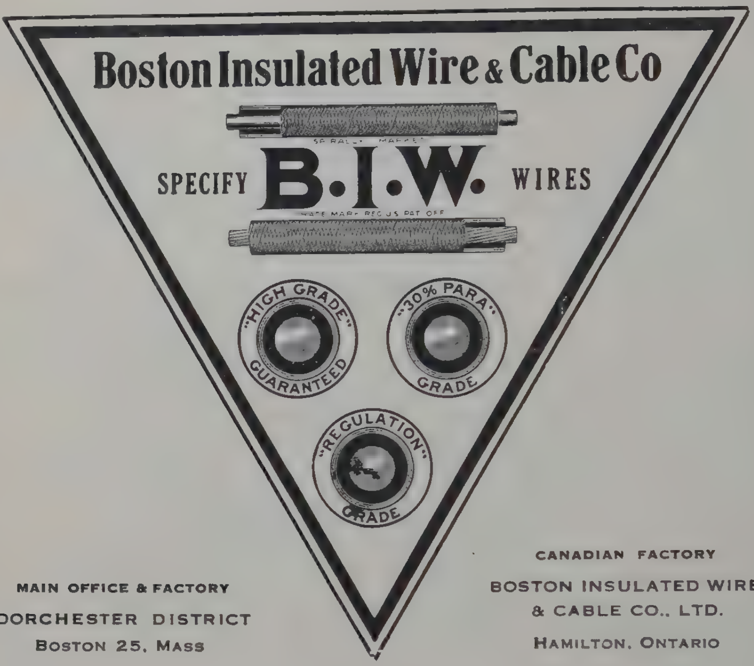

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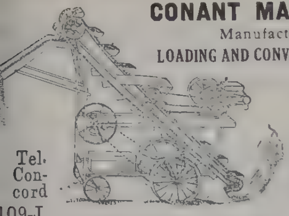

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